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Original research

The efficiency of induction and synchronisation of sexual desire in goats

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Abstract. One of the modern and widely used biotechnological methods for increasing the efficiency of animal reproduction is oestrus synchronization, which allows to reduce economic costs significantly. Using this method, a slight increase in the cost of processing animals is compensated by a significant decrease in labour costs, an increase in the technological efficiency of insemination and parturition, and the absence of costs for maintaining teasers. As a result, direct costs for reproduction might be reduced by a total of 50–60%. Induction and synchronization of sexual heat in goats have been used since the 1970s of the 20th century, however, in our country, such a biotechnological method of regulating reproductive function is just beginning to be practised, but the results of such implementations are not available in the literary sources. Therefore, the goal of our research was to determine the effectiveness of oestrus induction and synchronization in goats under specific farm conditions in Ukraine. The experiments were conducted between April 2021 and February 2022 in «Agrosvit» dairy farm in Shestakove village, Chuguyiv district, Kharkiv region, on goats of Alpine and Zaanen breeds, aged 2–4 years, with a live weight of 35–55 kg. A total of 368 goats having ≤ 1 litre of milk production starting from the 180th day of lactation, were involved in this trial. The synchronization protocol included the insertion of an intravaginal sponge with progestogen (day 0) (Chronogest CR polyester-polyurethane vaginal sponge, 20 mg of chronolone, intravaginally), injections of prostaglandin (Oestrophan, 0.2 ml, intramuscularly), and chorionic gonadotropin (Sergon, 500 OD, 1 ml, intramuscularly) (day 9), removal of the progesterone sponge (day 11), detection of heat (day 12) and insemination (day 13). Pregnancy diagnosis was determined by ultrasound examination on day 40 after artificial insemination. In our studies, using an oestrus induction and synchronization protocol based on progestogen sponge, prostaglandin and chorionic gonadotropin, 93.7% of treated goats were inseminated with a fertility rate of 158.9%. According to the results of the study, it can be concluded that oestrus induction and synchronization in goats is an effective biotechnological technique that allows increasing the efficiency of the use of genetic resources of high-value animals significantly, to increase the scale of their participation in the process of reproduction of livestock while maintaining a high level of physiological functions of the reproductive system. In particular, such studies will help to determine the most appropriate oestrus synchronization protocol and to better understand the effect on sexual behaviour and hormonal influence, and to inseminate goats at the most optimal time, in a short time, with a shortened period of kidding.

Keywords: oestrus; insemination; intravaginal sponge; heat; small cattle

Ефективність індукції та синхронізації статевої охоти у кіз

Анотація. Одним із сучасних і все більш широко застосовуваних у селекції біотехнологічних методів підвищення ефективності відтворення тварин є синхронізація охоти, який дозволяє значно зменшити господарські та економічні витрати. За застосування цього методу незначне підвищення витрат на обробку тварин компенсується значним зниженням трудовитрат, підвищенням технологічності проведення осіменіння та окоту, відсутністю витрат на утримання пробників. У підсумку прямі видатки на відтворення знижуються загалом на 50–60%. Індукція та синхронізація статевої охоти у кіз застосовується з 70-х років 20 століття, натомість в нашій країні такий біотехнологічний метод регуляції репродуктивної функції лише починає практикуватися, але результатів таких впроваджень немає у доступних літературних джерелах. Тож метою наших досліджень було визначення ефективності індукції та синхронізації статевої охоти у кіз в умовах конкретного козівницького господарства України. Досліди проводилися протягом квітня 2021 р. – лютого 2022 р. в умовах СТОВ «Агросвіт» села Шестакове Чугуївського району Харківської області на козах альпійської та зааненської порід, віком 2–4 роки, живою масою 35–55 кг. В експерименті було задіяно 368 голів кіз. Постановці на схему синхронізації статевої охоти

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підлягали тварини, які мали надої ≤ 1 л молока, починаючи з 180-ї доби лактації. Протокол синхронізації включав введення губки з прогестагеном (день 0), ін'єкції простагландину та хоріонічного гонадотропіну (день 9), вилучення губки з прогестероном (день 11), виявлення охоти (день 12), осіменіння (день 13). Моніторинг результатів здійснювали шляхом проведення ультразвукового дослідження на 40-й день після штучного осіменіння. У наших дослідженнях, за використання протоколу індукції та синхронізації з губкою з прогестагеном (поліестер-поліуретанові вагінальні песарії Chronogest CR, 20 мг хронолону, інтравагінально), простагландином (Oestrophan, 0,2 мл, внутрішньом'язово) та хоріонічним гонадотропіном (Sergon, 500 ОД (1 мл), внутрішньом'язово) було осіменено 93,7% оброблених кіз з рівнем плодовитості 158,9%. Таким чином, індукція та синхронізація статевої охоти є ефективним біотехнологічним прийомом, який дозволяє суттєво підвищити ефективність використання генетичних ресурсів високоцінних тварин, збільшити масштаби їх участі у процесі відтворення поголів'я зі збереженням на високому рівні фізіологічних функцій репродуктивної системи. Зокрема такі дослідження допоможуть визначити найбільш відповідний протокол синхронізації тічки та краще зрозуміти вплив на статеву поведінку та гормональний вплив і провести осіменіння кіз в найбільш оптимальний час, за короткий термін та зі стислими термінами окоту.

Ключові слова: еструс; осіменіння; інтравагінальні песарії; тічка; дрібна рогата худоба

Introduction

The intensification of goat breeding is determined by the efficiency of reproduction as a component of the industry management technology. An important implementation mechanism is the use of artificial insemination (AI), which is limited by the significant variability of the length of the sexual cycle in goats. Under the existing system of reproduction of the goat herd, based on the natural duration and alternation of sexual cycles, insemination of goats is carried out during two sexual cycles of 38–46 days, and sometimes the period of insemination lasts up to 60 days. This results in very prolonged kidding. The presence of goats of different ages in the herd creates great difficulties in the management of young animals and ultimately leads to a decrease in the rate of reproduction of the herd and uneven production of milk during lactation (Malahova et al., 2006; Ajbazov et al., 2012, 2013; Aksenova et al., 2012; Habeeb & Kutzler, 2021).

Oestrus induction and synchronization is a current and widespread biotechnological method for increasing the reproductive efficiency in small ruminants, which allows a reduction in costs significantly (Whitley & Jackson, 2004; Ajbazov et al., 2006, 2013; Malahova et al., 2006; Mamontova, 2015; Skljarov et al., 2015; Kirikovich et al., 2019). Using this method, a slight increase in the cost of processing animals is compensated by a significant decrease in labour costs, an increase in the technological efficiency of insemination and parturition, and the absence of costs for maintaining buck teasers. As a result, direct costs for reproduction are reduced by a total of 50-60% (Ajbazov et al., 2012).

Oestrus induction and synchronization in goats have been used since the 70s of the 20th century. However, in our country, the biotechnological methods of regulating reproductive function are just beginning to be practised, but the results of such implementations are not available. Therefore, the goal of this research was to determine the effectiveness of oestrus induction and synchronization in goats under goat farm conditions in Ukraine.

Materials and methods

The experiments were conducted from April 2021 to February 2022 in the «Agrosvit» dairy farm (Shestakove village, Chuguyiv district, Kharkiv region, Ukraine), on clinically healthy and well-nourished goats of Alpine and Zaanen breeds, aged 2–4 years, with a live weight of 35–55 kg.

The animals were kept indoors in compliance with veterinary, sanitary and hygienic standards, they were fed following the standards of feeding, with free access to water of appropriate quality (Suharl'ov, 2002).

Treatments were administered in groups having a maximum of 25–50 goats to be sure that all the animals were managed at the correct time. The following protocol was used for the oestrus induction and synchronization in goats under the conditions of this farm (Figure).

For oestrus induction and synchronization, sponges containing 20 mg of chronolone (polyester-polyurethane vaginal sponge Chronogest CR containing flugestone acetate, MSD Santé Animale, France) were inserted intravaginally. On day 9, 0.2 ml of cloprostenol (a synthetic analogue of prostaglandin F2α (PGF2α); Oestrophan,

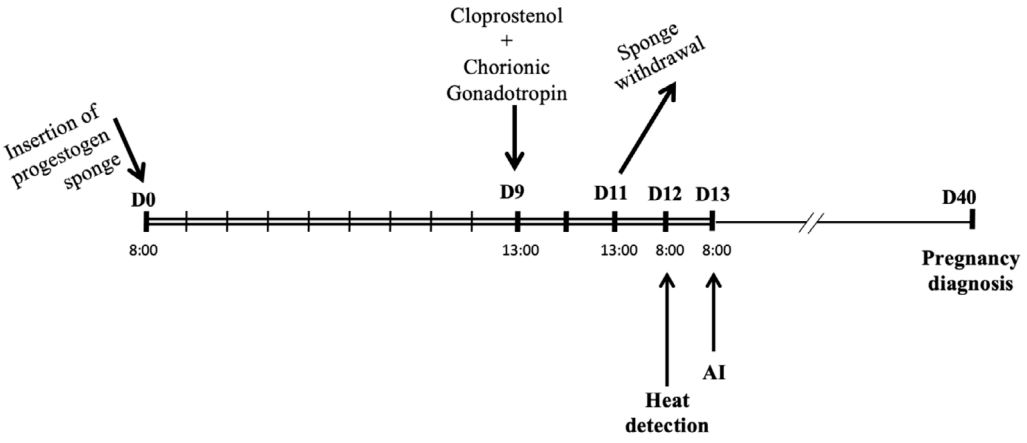

Figure. Scheme of the oestrus synchronization used in this trial

Bioveta, Poland) and 500 IU of equine chorionic gonadotrophin (eCG) (Sergon, Bioveta, Poland) were intramuscularly administered. Eleven days later, sponges were withdrawn and oestrus detection was carried out on the following day.

Oestrus heat was checked using teaser bucks and only those goats showing evident heat signs were inseminated. Qualified technicians conducted the artificial insemination at 43±0.5 h after the sponge withdrawal.

Female goats were artificially inseminated with the use of deconserved sperm following the requirements of the Instructions for Artificial Insemination of Sheep and Goats – with an activity of at least 4 points (in a sperm dose of 60–80 million spermatozoa with rectilinear translational movement), except for frozen-thawed sperm of imported breeders – with activity 3.0–3.5 points (Instrukcija, 2003).

The goats were restrained to a standing position. After the perineal and vulvar areas were cleaned, the AI catheter was intravaginally inserted; using a lubricated speculum with a light source to visualize the entry of the cervix, and the semen was deposited through the cervical rings to reach the uterus, when possible.

A pregnancy diagnosis was made on day 40 after the AI. It used an ultrasonographic scanner Medelcom Diagnostic Ultrasound System SLE-101PC equipped with a 6.0 MHz linear array transductor. Probe was placed in the inguinal area and animals were considered pregnant when foetuses were visualised.

The conception rate was calculated as the pregnant goats divided by the total inseminated goats × 100. The kidding rate was deemed to be the goats that had parturition divided by the total number of inseminated goats. The prolificity rate was determined as the number of born kids divided by the total number of inseminated goats.

Results

According to the data obtained, 368 goats were treated for oestrus synchronisation, but only 345 goats (93.7%) had signs of oestrus detected by teaser bucks (Table).

A total of 294 goats (85.2%) became pregnant after artificial insemination. In 51 goats (14.8%), signs of oestrus were detected after treatment but they did not become pregnant after insemination. At parturition, the prolificity rate was calculated; it reached 158.9%.

Discussion

Accordingly, the use of oestrus induction and synchronization protocols allows us to achieve several goals (Ajbazov et al., 2013). First, there is no need to wait for the spontaneous arrival of animals in heat. Secondly, the synchronization method allows for regulating the number of animals that come in heat every day and makes artificial insemination predictable. After synchronization, sexual desire appears simultaneously within 36–48 hours after treatment in 90–100% of animals. This allows you to plan the beginning of the insemination campaign and regulate the number of goats in the breeding season. Thirdly, with well-organized synchronization, there is no need to keep buck teasers in the herd and carry out daily time-consuming teasing to detect goats in heat. At the same time, all offspring must be guaranteed to be obtained from the breeders intended for insemination. Fourthly, the terms of artificial insemination and, accordingly, the parturition period is significantly shortened. Depending on the possibilities and wishes of the agricultural producer, as well as the management conditions, insemination of the herd (600–650 goats) could take 8–10 days (instead of the usual 35–40); at the same time, parturitions will require 15–20 days (instead of 40–60).

Using this reproductive procedure, a slight increase in the cost of processing animals is compensated by a significant decrease in labour costs, an increase in the technological efficiency of insemination and kidding, and the absence of costs for maintaining buck teasers. As a result, direct costs for reproduction are reduced by a total of 50–60%.

Although the fertility of oestrus synchronized goats was slightly lower than that in natural mount (by 10.0–13.3%), multiple fertility in synchronized goats was higher by 14.5–25.0% (Ajbazov & Aksenova, 2012).

Cherkesova (2005) notes that in goat females under oestrus synchronization, the duration of oestrus was reduced by an average of 1.4 times and comprised 31 hours. In this took place, ovulation begins between 21–23 hours after the start of oestrus, but in most animals, it occurs between 24-29 hours.

Induction and synchronization schemes in goats include hormones, particularly melatonin, gonadotropin / gonadotropin-releasing hormone (GnRH) or agonists, progestogens, and prostaglandins, alone or in combination, administered orally, by injection, or by intravaginal devices (Kusina et al., 2000; Whitley and Jackson, 2004; Arrebola et al., 2012, 2022; Parmar et al., 2020; Zuñiga-Garcia et al., 2020; Anggraeni et al., 2021; Farooqi et al., 2021; Habeeb & Kutzler, 2021; Rivas-Muñoz et al., 2021; Skliarov et al., 2021; Khandoker, 2022; Hidayah et al., 2022; Wondim et al., 2022). And the essence of the hormonal stimulation for sexual heat induction is that the luteal phase of the sexual cycle is artificially simulated by the introduction of progesterone or other progestagen-based drugs in females. The subsequent introduction of gonadotropic hormones stimulates the development of follicles in the ovaries and then, the manifestation of all the phenomena of the natural sexual cycle – oestrus, sexual heat and ovulation (Ajbazov et al., 2013).

The use of intravaginal sponges containing synthetic analogues of progesterone has become widespread for oestrus synchronization in small ruminants during and outside the breeding season. These devices are intravaginally maintained for a wide range period (from 9 to 19 days, and currently they are been reduced to 5–7 days), and are used in combination with eCG, which is injected during or 48 hours before their removal, as well as in combination with other drugs. Oestrus occurs in 90% of the treated animals within 24–48 hours after the device removal, but results are variable (Powell et al., 1996; Romano, 1998; Wildeus, 2000; Kirikovich et al., 2019).

In our studies, the protocol for induction and synchronization of sexual desire in goats involved the use of a sponge with a progestogen (polyester-polyurethane vaginal sponge Chronogest CR containing 20 mg of chronolone), which was administered intravaginally. Intramuscular injections of Oestrophan (Bioveta, Poland) in a dose of 0.2 ml were used as a prostaglandin, and Sergon (Bioveta, Poland) was used as a chorionic gonadotropin, which was administered intramuscularly, 500 units (1 ml). In total, 345 female goats were inseminated, which is 93.7%. As a result, 294 animals were born with a fertility rate of 158.9%.

Zhao et al. (2010) experimented to select an effective method of oestrus synchronization in goats (*Capra hircus*): the first group was

Table – Effectiveness of oestrus induction and synchronization in goats

Treated animals, n	Oestrous detection rate, % / (N_1 / n)	Conception rate, % / (N_2 / N_1)	Prolificity rate, % / (N_3 / N_2)
368	93.7 / (345 / 368)	85.2 / (294 / 345)	158.9 (467 / 294)

Note: N_1 – percentage from n, N_2 – percentage from N_1, N_3 – percentage from N_2 for a respective index

synchronized using intravaginal sponges impregnated with 30 mg of Levonorgestrel, administered for 10 days. Goats of the second, third, and fourth groups were subsequently injected with 25 IU follicle-stimulating hormone (FSH), 0.05 mg PGF2α, and 25 IU FSH + 0.05 mg PGF2α during sponge removal, respectively. The results showed that all the treatments used were capable of inducing and synchronizing oestrus in goats. According to oestrous response and economy, the use of intravaginal sponges impregnated with 30 mg of Levonorgestrel and 0.05 mg of PGF2α is the first choice for oestrus synchronization, and 95.0% of synchronized females showed oestrus, which was significantly higher than the first group. The percentage of ovulation in the third and fourth groups was the same (95.0%), but significantly higher than in the first group.

Sen & Onder (2016) determined the effect of oestrus synchronization programs on the timing of parturition and some reproductive characteristics of Saanen goats. Their oestrus was synchronized as follows: using intravaginal sponges containing 30 mg flugestone acetate for 11 days after intramuscular injection of 500 IU eCG (group PP) or only intravaginal sponges (group P) and natural oestrus (control, C). The kidding rate and litter size in group PP were higher than those of goats in groups C and P. The neonatal mortality rate in group PP was higher than in groups C and P. The duration of the kidding period in goats of group C was longer than in goats of groups P and PP. Births showed a unimodal distribution, with maximum births during the daylight and minimum births at midnight in all goats. Parturitions that occurred during the daylight in groups P and PP were longer than those of group C. The results of this study may indicate that the oestrus synchronization allowed to shorten the length of the oestrous period, concentrate the time of parturition during the daylight hours and increase the reproductive ability of Saanen goats.

Titi et al. (2010) reported that the use of GnRH–PGF2α was effective, the addition of progestogen sponges at the time of GnRH administration improved reproductive parameters.

Nadolu et al. (2022) examined the reproductive performance of Alpina goats synchronized with Chronogest intravaginal sponges for 11 days and 400 IU eCG (Folligon, MSD) without prostaglandin, and they evaluated the cases of pseudo-gestation (4.1%), kidding rate (56.8%) and prolificacy (310.7%). The authors reported that eliminating the administration of prostaglandins could reduce the risk of abortion due to lysis of corpora lutea in presumably pregnant goats during the treatment.

A study by Kanduri (2022) was conducted to evaluate the effectiveness of different oestrus timing protocols on the oestrus response and progesterone profile in local Mahabubnagar goats. One group (GPG) was treated with GnRH on day 0, PGF2α on day 7 and GnRH on day 9. The second group (PPG) was treated with PGF2α on days 0 and 7, but GnRH on day 9. The third group (SPG) was treated using vaginal sponges for 9 days. PGF2α was administered on day 8, sponges were removed on day 9, and GnRH was administered. The fourth group (SP) had vaginal sponges removed on the 9th day and eCG was administered. The results of this study showed that the SP group had the best treatment regimen in terms of onset of oestrus (32.4 hours, ranging from 26.5 to 38.3 hours) and duration of oestrus (52.2 hours, ranging from 48.7 to 55.7 hours).

Salleh et al. (2021) Boer does were divided into three groups with different durations of intravaginal CIDR for 14 (two groups) or 9 days (one group) – 0.5 ml cloprostenol (PGF2α) was administered intramuscularly to all groups after CIDR removal, and only groups eCG 14 and eCG 9 were administered 200 IU of eCG intramuscularly. The percentage of females in heat 24–72 hours after CIDR removal was significantly higher in the eCG group compared to the non-eCG group. The number of females showing signs of oestrus within 24-28 hours of CIDR removal was significantly higher in the shorter period (9 days) group compared to the 14-day CIDR groups. P4 concentration 24 h after CIDR removal and LH concentration were not significantly different in all groups. The LH peak time in the non-eCG group was significantly delayed compared to the 9-day CIDR and eCG group. The authors recommend using treatment within 9 days of CIDR, as the oestrous cycle may be shortened.

Freitas et al. (1997) evaluated the ability to improve the timing of oestrus and the luteinizing hormone (LH) peak using different progestogens, fluorogestone acetate (FGA) or norgestomet, and routes of administration (vaginal sponge or subcutaneous ear implant). In two experiments, goats were treated with one of three progestogens: 1) a vaginal sponge with 45 mg of FGA; 2) a half of the implant with norgestomet, or 3) a whole implant containing 3 mg of norgestomet. Progestogens were left in goat females for 11 days and were accompanied by intramuscular injections of 400 or 500 IU equine chorionic gonadotrophin (eCG) and 50 μg of a PGF2α analogue (cloprostenol) were administered 48 hours before progestogen removal. As a result, goats that received semi-implants began oestrus earlier than those that received vaginal sponges (27.8 h vs. 33.0 h, respectively). However, the interval between the time of onset of oestrus and the LH peak was more variable in goats treated with semi-implants. No effect of progestagen treatment was observed either on the time or on the variability of the onset of oestrus. The percentage of ovulating goats as well as the overall fertility rate were higher in goats receiving vaginal sponges (98.2% and 75.0%, respectively) than in those receiving semi-implants (81.8% and 45.5%, respectively). However, no significant differences were observed for the same parameters in animals that got implants (86.3% and 58.8%, respectively). In conclusion, the timing of oestrus with a norgestomet implant or semi-implant did not reduce variability in oestrus onset and LH peak. Fertility was generally lower in goats receiving a whole implant and was significantly reduced in goats receiving a half implant.

Freitas et al. (1996) studied the effect of ovarian status (presence of corpora lutea and follicles) on the time of onset of oestrus, LH peak and ovulation rate during synchronized oestrus in Alpine and Zaanen goats. Females were treated for 11 days with 3 mg norgestomet implants or 45 mg FGA sponges. They also received 400 IU of eCG and 50 μg of a PGF2α analogue on day 9 of progestagen priming. It was determined that the number of follicles on days 0 and 9 of progestogen treatment was not related to the time of onset of oestrus nor the onset of the LH peak or ovulation rate. The number of corpora lutea on day 9 affected the time of the LH peak, but not the time of the onset of oestrus. Thus, in the case of 2 or 3 corpora lutea on day 9, the LH peak was observed 46.9 hours after the end of progestagen treatment,

East & Rowe (1989) compared two sources of progestin (subcutaneous implant and vaginal sponge) in combination with eCG for the induction of oestrus in lactating and nulliparous dairy goats during the transition from anestrus to oestrus. Compared with the untreated control group, both progestins demonstrated equal efficacy to induce behavioural oestrus and pregnancy. Fertility rates were similar for both groups, and lactation status and breed did not affect the pregnancy. Treatment with progestins and eCG was successful in increasing the number of winter foals, thereby increasing winter milk production.

Özmen et al. (2021) investigated the effect of the administration of eCG (500 IU) at two different periods on oestrus and pregnancy rates and the number of offspring in Kilis goats. Animals were treated with a progesterone sponge (20 mg flugestone acetate) for 11 days and 250 μg of PGF2α two days before removing the sponge. The eCG was used in group 1 during two days before the removal of the sponge, and in group 2 it was used on the day of its removal. The pregnancy rate (54.6% vs. 25.0%) and the total number of offspring (7 vs. 3) in group 1 were higher than in group 2. The authors concluded that it may be more beneficial to apply eCG 48 hours before sponge removal rather than during sponge removal outside the breeding season.

Kupferschmied & Muther (1977) proposed the following

scheme for synchronizing oestrus in goats: 1st day – introduction of intravaginal sponges impregnated with 45 mg of progestagen; 16th day – intramuscular injection of FFA in a dose of 400 IU, 18th day – removal of intravaginal sponges and 19-20th day – artificial insemination. In other studies (González-Stagnaro, 1974), the use of intravaginal sponges impregnated with 45 mg of fluorogestone acetate (FGA) allowed insemination of goats 13-54 hours after the removal of progestogens.

A study by Kumar et al. (2018) was conducted to investigate the effectiveness of the best oestrus synchronization protocols on reproductive performance in goats. Treatment protocols: 1) introduction of PGF2α with an interval of 12 days; 2) vaginal sponges treated with progesterone were impregnated into the vagina for 12 days; 3) vaginal sponges for 12 days with eCG. at the time of sponge removal and 4) vaginal sponge + eCG + GnRH. The best results were obtained using vaginal sponge + eCG + GnRH, in particular: pregnancy rate was 84.2%, kidding rate – 126.3%, litter size – 1.5, and twinning rate – 33.3%.

According to literature data (Sang-tae Shin et al., 1998), one of the most optimal options for inducing oestrus in goats is the option with the joint use of FSH and medroxyprogesterone acetate (MAP) (intravaginal sponges containing 60 mg MAP) in comparison with the use of FSH and gonadotropin alone in complexes with progesterone, as well as ear implants with norgestomet (Bretzlaff et al., 1989). According to other data (Amoah & Gelaye, 1989), it remains acceptable to use progestogens, gonadotropins and their analogues in the mating and anoestrous periods of the year to induce oestrus in goats. The ease of use of ear implants (Synchromate-B) makes them more profitable compared to vaginal means. FSH-P is superior to purified equine gonadotropin (eCG) in fertility, but their multiple injections make the process time-consuming. The problem, in this case, can be solved by using subcutaneous implants, which provide a constant osmotic infusion of the hormone. The use of melatonin can restore sexual cyclicity in the non-mating period of the year, and the use of prostaglandins greatly simplifies the stimulation procedure, but with a more severe effect on the body in the luteal phase of the sexual cycle. It is recommended to synchronize oestrus in goats with the help of ear implants, treating the injection site with chloroethyl for pain relief (Goldman et al., 2002).

Kirikovich et al. (2019) established that the most optimal are the 4- and 5-day oestrus synchronization schemes in animals with the use of 500 IU of eCG. Signs of sexual desire within 6 days after drug administration were observed in 75.0–83.3% of goats, while in the group of animals administered 400 IU, this indicator was 50.0–71.4% in 6 days 66.7–71.4% in 9 days, respectively.

As a result of the experiment, there was established that the use of sponges for 6 and 12 days allows for inducing oestrus in 100% of animals, but the sponge used for 9 days entailed in oestrus of 66.7% of animals. The period from the removal of the implant to the manifestation of the first signs of appetite in animals under the 12-day scheme was 17.2 hours, but under the 9- and 6-day – 25.7 and 27.2 hours on average, respectively.

The duration of intercourse with the action of the sponge for 12 days was minimal and amounted to 20.5 hours, which is 5.3 and 7.5 hours shorter than in the groups where the period of exposure to the reproductive system of intravaginal inserts was 9 and 6 days, respectively.

With an increase in the time of progestagen use in females from 6 to 12 days, the time of onset of oestrus is reduced by 10 hours and the duration of oestrus by 7.5 hours. It was determined that the injection of eCG into the animals 48 hours before the removal of the insert allows achieving the synchronicity in the manifestation of signs of oestrus 30 hours after its removal in 100% of animals, while in schemes without application, the desire was observed in 77.8% of females. It is necessary to note that the use of the drug eCG made it possible to reduce the duration of sexual desire by 5.0 hours (18.0 vs. 23.0) when using a 12-day scheme, by 4.3 (24.7 vs. 29.0) and by 4 0 (26.0 vs. 30.0) hours – for using 9- and 6-day animal processing schemes, respectively. Thus, the complex use of progestagen sponges and eCG allows for achieving maximum results by reducing the time from the moment of removal of the insert to the manifestation of oestrus in goats by 3.2 hours (21.7 vs. 24.9) in total according to the experiment.

The complex use of progestagen and gonadotropic drugs in schemes of synchronization-stimulation of sexual desire in transgenic females of random age for a period of 6 and 12 days after the introduction of intravaginal implants allows to induce oestrus in 100% of cases and shortens the time of onset of sexual heat in animals from the moment of removal of progestogen sponges. While the use of a 2.5% solution of progesterone helps to obtain 66.7-83.3% of animals that have shown sexual heat for a longer period of 6-9 days, which complicates the work of carrying out planned insemination of animals. The use of intravaginal implants in combination with eCG in the schemes of synchronization-stimulation of sexual desire in transgenic females allows to effectively and in the shortest possible time to carry out work on inducing oestrus in goats, shorten the duration of sexual heat in animals and contributes to a more synchronous manifestation of oestrus in the anoestrous period of animal reproduction (Kirikovich et al., 2019).

Solihati et al. (2021) determined the oestrous profile of Etawah Crossbred goats after oestrous synchronization by different methods: Type 1 (T1) – 14 days of intravaginal implant 60 mg progesterone (MPA); Type 2 (T2) – two injections of 5 mg PGF2α (dinoprost tromethamine; Lutalyse) 11 days apart; Type 3 (T3) – 10 days of intravaginal implantation of 60 mg of progesterone (MPA) + injection of 5 mg of PGF2α 48 hours before removal). The results showed that oestrus behaviour and changes in colour and size of the vulva did not differ significantly in contrast to the duration of oestrus. The duration of oestrus in T1 (31.3 hours) and T2 (31.1 hours) was significantly longer than in T3 (11.4 hours). It was concluded that different methods of oestrus synchronization had the same effect on the quality of oestrus but had different effects on its duration.

Amarantidis et al. (2004) evaluated the efficiency of oestrus synchronization and reproductive performance in aboriginal goats (*Capra prisca*) during the breeding season. Treatments included: FGA-impregnated sponges, FGA-impregnated sponges plus intramuscular injection of 400 IU eCG, double intramuscular injection of PGF2α, FGA-impregnated sponges plus intramuscular injection of PGF2α, and sponges impregnated with FGA plus intramuscular injection of PGF2α and 400 IU eCG. Oestrous response to treatment was ≥95%. The onset of oestrus and duration of oestrus differed significantly by treatment, whereas fertility rate, gestation length, fecundity and type of parturition did not differ. The use of FGA-impregnated sponges and FGA-impregnated sponges accompanied by the intramuscular injection of 400 IU eCG was effective in achieving early and compact oestrus synchronization in goats.

In a comparative study, Baril et al. (1993) analysed the effect of vaginal progestogen tampons in goats on the percentage of animals showing signs of oestrus and their fertility. The results showed that exposure to a 45 mg fluorogestone acetate sponge for 11 days and subsequent administration of 400 IU eCG and 50 μg cloprostenol 48 hours before withdrawal promoted oestrus in 81–98% of animals and fertility at the level of 62–65%.

The purpose of the study by Matsumoto et al. (2021) was the development of an oestrus synchronization protocol using intravaginal administration of oestradiol benzoate (EB) capsules in goats. Two types of capsules were produced: an EB capsule that melted immediately after administration and a sustained-release (SR) EB capsule that dissolved slowly and reached a peak after 24 hours. Goats with a functional corpus luteum were injected intramuscularly with PGF2α, and after 24 hours – 1 mg of EV solution intramuscularly (PGF2α + 24IM) or 1 mg of EV capsule intravaginally (PGF2α +

24EB). The SR EB capsule was administered intravaginally during the administration of PGF2α (PGF2α + SR). The control group received only PGF2α. Oestrus was observed in all groups within 72 hours after administration of PGF2α. The onset of oestrus was not significantly different between the PGF2α + 24IM and PGF2α + SR groups but was earlier than in the control group. The concentration of oestradiol in the PGF2α + SR group reached a maximum of 11.5 h after the administration of EB and PGF2α. Peak oestradiol concentrations were not significantly different between the PGF2α + 24IM and PGF2α + SR groups (78.0 pg/ml and 64.0 pg/ml, respectively) and were higher than in the PGF2α + 24EB and control groups (27.3 pg/ml and 14.6 pg/ml). These results suggest that intravaginal administration of EB capsules with an oestrus-synchronized sustained-release base is an alternative to intramuscular administration.

The purpose of the research Bitaraf et al. (2007) evaluated three methods of oestrus synchronization, namely: CIDR, intravaginal sponges impregnated with (FGA), and cloprostenol (PGF2α analogue) in Nadooshani goats of Yazd province (Iran). No significant difference was observed between the treatment methods in the interval between the end of the synchronization protocol and the standing heat (range: from 23 to 35 hours) and the interval between the time of standing heat and insemination (range: from 15 to 27 hours). Synchronization methods did not significantly affect the level of progesterone in blood serum (4.80 ng/ml), litter size (1.32), non-return rate to oestrus and the kidding rate. Synchronization methods did not significantly affect prolificacy and fecundity, however, the cloprostenol method turned out to be more convenient and economical under the conditions of this experiment.

Malahova & Novopashina (2011) concluded, based on research on goats, that the use of a sponge with progestagen for 16 days requires eCG on the day of pessary removal, which will significantly reduce the cost of labour for processing animals. When shortening the period of treatment with progestogens to 14 days, eCG should be performed 24 hours after removal of the sponge. The authors found that the time of eCG administration after pessary removal for 16 days did not significantly affect the effectiveness of hormonal treatment. The number of oestrous goats for eCG administration immediately after pessary removal or 24 hours later was 83.3% and 80.0%, respectively. However, the injection of eCG simultaneously with the removal of sponges significantly reduces the cost of labour for processing animals. By shortening the treatment period to 14 days, increasing the time between the removal of the sponge and the introduction of gonadotropin to 24 hours increased the stimulating effect by 3.3%.

According to their research, Shejko et al. (2004) made some conclusions:

– The use of various hormonal agents and their complexes allows for controlling the synchronization and stimulation of the drive-in goats with high efficiency.

– The use of Folligon (eCG) in a dose of 500 IU is optimal and allows 72.7% of goats to be willing to inseminate from the first insemination of 55.6%.

– Complex use of 37.5–50 mg of a 2.5% solution of progesterone and 400–500 IU Folligon promotes the manifestation of oestrus in 66.7–83.3% of animals. The use of a progestagen in a dose of 50 mg with an injection of 500 IU of eCG allows for inducing oestrus within 6 days in 83.3% of animals.

– Analogue of prostaglandin F2α Oestrophan is a highly effective means of inducing sexual heat in goats. A dose of Oestrophan 200–300 μg allows synchronizing oestrus within 6-9 days in 75-100% of animals.

– The use of gonadotropin-releasing hormone in schemes for synchronizing and stimulating oestrus at the time of manifestation of sexual heat in animals allows for reducing the duration of oestrus in goats by 1.4–7.3 hours compared to the control. The dose of Gn-RH 15 mg is optimal, minimal fluctuations in the duration of the animal's appetite (27–37 hours) were noted.

As reported by Cherkesova (2005), synchronization of sexual heat in goats is an effective biotechnological technique and allows the insemination of goats at the most optimal time, in a short time (10 days), which leads to a short period of farrowing – 19 days. Obtaining one-year-old kids reduces the costs of their care and rearing and allows for an increase in the safety of young kids before weaning up to 95–98%. At the same time, the physiological functions of goats related to reproduction are maintained at a high level.

Conclusion

Using a protocol of induction and synchronization with a sponge with progestagen (polyester-polyurethane vaginal sponge Chronogest CR, 20 mg of chronolone intravaginally), prostaglandin (Oestrophan, 0.2 ml intramuscularly) and chorionic gonadotropin (Sergon, 500 IU intramuscular) promoted insemination in 93.7% of the treated goats with a fertility rate of 158.9%.

The general conclusion is that the induction and synchronization of sexual desire is an effective biotechnological technique that allows you to significantly increase the efficiency of the use of genetic resources of high-value animals, increase the scale of their participation in the process of reproduction of livestock while maintaining a high level of physiological functions of the reproductive system. In particular, such studies will help to determine the most appropriate oestrus synchronization protocol and to better understand the effect on sexual behaviour and hormonal influence and to inseminate goats at the most optimal time, in a short time, with a shortened period of parturition.

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